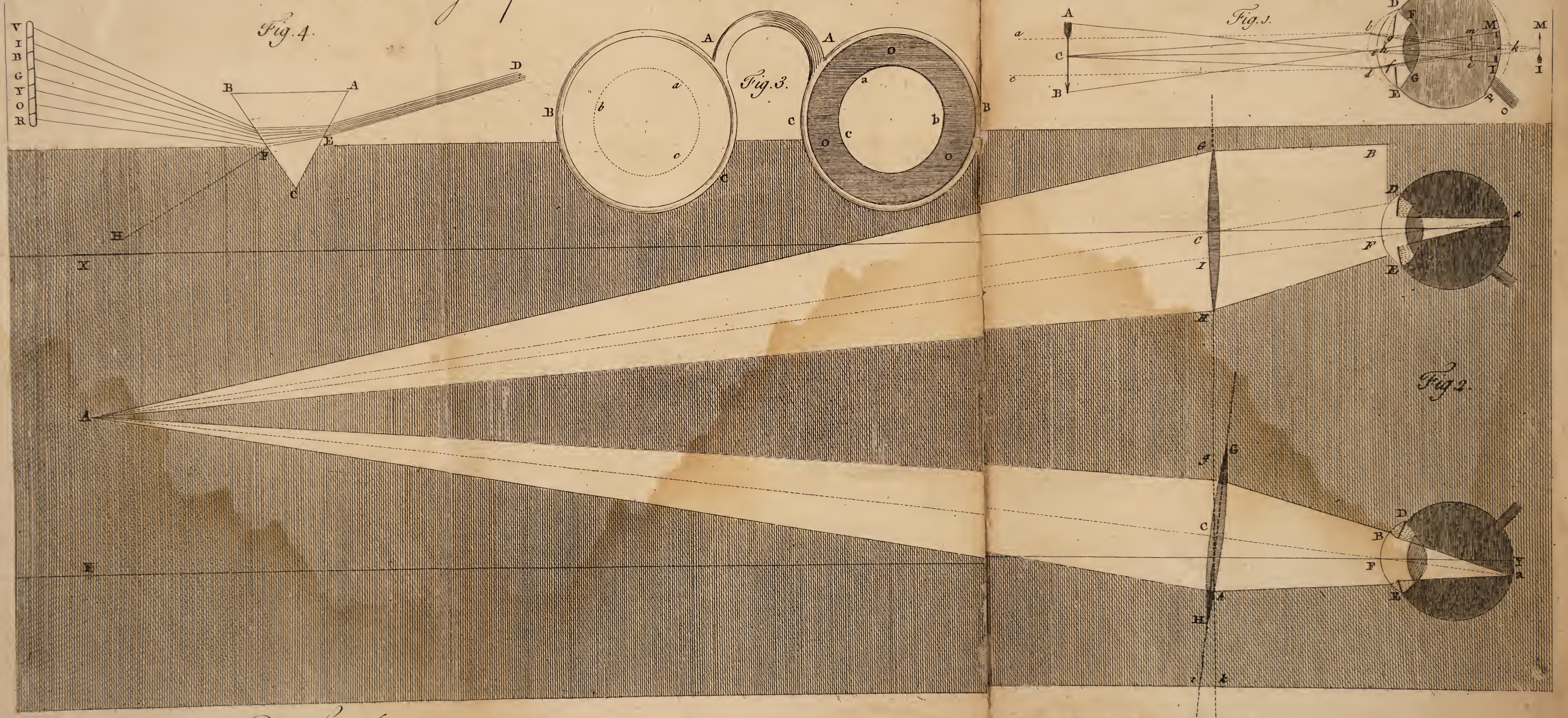
John Thompson

On Viſual Glaſses.

35603/P

The Advantage of VISUAL GLASSES above Spectacles demonstrated.



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15390

AN
ESSAY
ON
VISUAL GLASSES,

(Vulgarly called SPECTACLES)

Wherein it is ſhewn

From the Principles of OPTICS, and the
Nature of the EYE, that the common Structure
of thoſe Glaſſes is contrary to the Rules
of Art, to the Nature of Things, *&c.* and
very prejudicial to the EYES;

The Nature of VISION in the EYE explained,
and Glaſſes of a New Conſtruction propoſed.

The Whole illuſtrated by a large COPPER-PLATE-PRINT.

The SECOND EDITION.

By *B. MARTIN.*

LONDON:
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AN
ESSAY
ON
VISUAL GLASSES, &c.

I Propoſe here to treat, in a brief Manner, not of the *Antiquity*, or *optical Theory* of *Spectacles*, but of their Uſe in aſſiſting the Eye to ſee Objects diſtinctly, when the natural Form and Condition of it fail us; and to ſhew what is the neceſſary Conſtruction or Diſpoſition of thoſe *artificial Glaſſes* for anſwering that *important Purpoſe* in the beſt Manner poſſible.

In the Courſe of Nature, moſt People are obliged to know by Experience the great and univerſal Uſe of SPECTACLES, both *convex* and *concave*, eſpecially the former, concerning which Mr. *Molyneux* has this remarkable Paſſage:——"Were there no other Uſe of DIOPTRICS than that of Spectacles for defective Eyes, I ſhould think the Advantage that Mankind received thereby inferior to no other Benefit whatſoever, not abſolutely requiſite to the Support of Life. For as the Sight is the moſt noble and extenſive of all our Senſes, as we make the moſt frequent and conſtant Uſe of our Eyes in all the Actions and Concerns of human Life, ſurely that which relieves the Eyes when decayed, and ſupplies their Defects, rendering them uſeful when almoſt uſeleſs, muſt needs of all others be eſteemed of the greateſt Advantage. How melancholy is the Condition of him who only enjoys the Sight of what is immediately about him? With what Diſadvantage is he engaged in moſt of the Concerns of human Life? *Reading* is to him troubleſome; War more than ordinary dangerous, Trade and Commerce toilſome and unpleaſant. And ſo likewiſe on the other Hand, how forlorn would the *latter Part* of moſt Mens Lives prove, unleſs Spectacles were at hand to help their Eyes, and a little formed Piece of Glaſs ſupplied the Decays of Nature? The curious *Mechanic* engaged in any minute Work could no longer follow his Trade than to the 50th or 60th Year of his Age. The *Scholar* no longer converſe with his Books, or with an abſent Friend in a Letter. All after would be melancholy Idleneſs, or he muſt content himſelf to uſe another Man's Eyes for every Line. Thus forlorn was the State of moſt old Men, and many young, before this admirable Invention, which on this very Account cannot be praiſed too highly."

This Invention being of ſo great a Concernment to Mankind in general, will certainly command their Attention to every Propoſal for its Improvement; though it muſt be confeſſed there has ſcarcely any thing been done ſince they were firſt made that deſerves to be ſo eſteemed; perhaps no optic Inſtrument has been ſo little conſidered or altered ſince the firſt Conſtruction, as *Spectacles*. The Maker or Seller is not to be charged with this Neglect; but the *Optician* (I mean a Perſon ſkilled in the *The Theory of Optics)* who, though he has condeſcended often to treat of the Subject, has never yet pointed out the beſt Method of conſtructing them for Uſe, nor even ſo much as taken notice of that very Form and Diſpoſition of Glaſſes in this Inſtrument, which the *Science of Optics* points out, and makes neceſſary to their *Perfection*.

Among others, I myſelf have over-looked the Nature of this Inſtrument, till it fell into my Way to be more nearly intereſted in the Uſe of it. I before looked on it only as an uſeful Deduction from this Science, to others; but my own Eyes now beginning to require their Aſſiſtance, I began more particularly to conſider them, and eſpecially how and in what Manner they might be applied to the beſt Advantage for the Eyes, as I well knew the Manner in which Light affected that noble Organ.

I had not long reflected on the Subject, when I eaſily perceived the Errors of the common

Form; and wondered much, how it was poſſible for Glaſſes in ſuch frequent Uſe, to retain ſo long a Conſtruction *quite contrary to the Laws of Optics*, and, in the Courſe of a few Years, muſt prove ſo *very prejudicial to the Eyes*. I could no other Way account for it, but by conſidering that ſuch Glaſſes any Ways applied to the Eye, will aſſiſt the Sight; and though the Conſtruction were faulty enough, yet as that could not be immediately known by People who uſe them, it could be no Objection againſt them; and not only ſo, but they muſt have *them*, or none.

But ſince I was now to uſe them myſelf, I reſolved at once to have a Pair as perfect as my Skill in Optics, and the Form and Make of the Eye, could direct me to conſtruct, and the Reſult was as follows.

I. I conſidered the two Glaſſes of *common Spectacles* were placed both in the *ſame Plane*; and of Courſe their Axes were parallel to each other, and therefore could only be directed to Objects at a very *great Diſtance*, where we can ſee no Object with them at all.

II. That when we uſe Spectacles, the Axes of both Eyes are turned to the Object we view, and meet in a Point in it; as in *reading*, *writing*, *working with a Needle*, *&c.* And conſequently the Axes of the Eyes and of the Glaſſes are ſo far from coinciding (as they ought to do for *diſtinct Viſion*) that they make a conſiderable Angle with each other.

III. That by this Means the *principal Pencil of Rays*, or thoſe which belong to the Axes of the Glaſſes, which make the moſt perfect Part of the Image on the Bottom of the Eye, and which are neceſſary for perfect Viſion: I ſay, all theſe Rays the Eyes are deprived of in the common Form of Spectacles, and only thoſe Rays can enter the Eye from the Object we look at, as comes on *one Side of the Glaſs*, and are therefore *irregularly refracted* to the Eye, and ſo make the *Viſion in Proportion imperfect*.

IV. I conſidered (and it is well known by Experience) the *Action of Light upon the Eye* tends gradually to *weaken it*, and that therefore no more of ſuch an active Principle ſhould be admitted into ſo delicate and fine a Structure as that of the Eye, than was quite neceſſary to illuminate the *Object*, and make it ſufficiently viſible. But the common Size of Spectacle-Glaſſes pours in upon the Eye-Ball three Times as much as is neceſſary for this Purpoſe: and therefore are very prejudicial to the Eye in this Reſpect, as in Time it makes them *weak* and *watery*.

V. But further, it is well known, that only a particular Quantity of Light is proper for *perfect and diſtinct Viſion*, and that a greater or leſſer Degree of it always impairs and confuſes the Image, and conſequently the Viſion of the Object by it; and for this Purpoſe in *Microſcopes*, *Teleſcopes*, and *other optical Inſtru-*

ments, a Proviſion is made by proper Apertures and Diaphragms; but in *Spectacles*, where the Quantity of Light ſhould be in the higheſt Degree regulated and adjuſted, no Proviſion at all has been made; but the tender Syſtem of the Eye has been left defenceleſs to the conſtant Attacks of the *ſuperfluous and injurious Particles of Light.*

VI. Again, I conſidered that only thoſe Rays of Light which fall near the Axes of the Glaſſes, can be regularly refracted to the Eye, and conſequently only ſuch can make the Image, or Viſion of an Object in any Degree perfect: and therefore conſidering the unreaſonable Area or Largeneſs of the Surface of common Spectacles, there muſt neceſſarily be a great Quantity of Light that will not only annoy the Image by Suffuſion, but greatly vellicate the Eye, and render the Image imperfect by an *irregular Refraction* from all the extreme Parts of the Glaſs.

VII. By the Doctrine of the *different Refrangibility* of Light, we are taught by Sir *Iſaac Newton* to underſtand, that the Rays or Particles of Light are of very different Sizes or Magnitudes, and that therefore they muſt ſtrike the Parts of the Eye with very different Forces; that from hence ariſe the various *Ideas of Colours*; that thoſe Particles, which make the *red Colour*, are largeſt, as being leaſt refrangible; and thoſe which make the *violet Colour*, are moſt refrangible, and therefore of the *ſmalleſt Size*, conſequently their Action on the Eye will be eaſieſt, and of Courſe the *violet or purple coloured Glaſs* is the beſt of all for ſuch Purpoſes.

VIII. In the laſt Place it is to be obſerved, that the Image of an Object made by common compounded Light (as in *common Spectacles*) is not near ſo perfect as that made by one particular Sort of Rays; and that therefore *Viſion by a colouoed Glaſs* is moſt of all perfect, and ſhould be choſe by every judicious Perſon, where an exquiſite View of the Object is required.

Theſe are the Principles on which this *new Conſtruction of viſual Glaſſes* depend; that they are real and important Facts, and founded in the Nature of Things, no one who has ſtudied the *viſual Science* can have the leaſt Doubt of: but to illuſtrate ſuch an intereſting Affair, and make the whole of what I have ſaid as clear as poſſible, I ſhall give a Repreſentation of the Eye, the Spectacle-Glaſſes according to the *vulgar* and the *new Poſition*, and the Manner in which the Rays of Light proceed from an Object through both of them to the *Retona* in the Eye, which is the immediate *Organ of Light*. [See the Copper-Plate.]

A Deſcription of the Eye.

The Structure of this noble Organ is not leſs wonderful than the Power and Wiſdom by which it was formed. In this natural State every Part has tde very Form and Office which the Laws of Optics require for the moſt perfect Viſion of an Object, as will appear from the following Conſiderations.

1. Viſion in the Eye is effected by Rays of Light reflecting through the Eye D E P Q [*Fig.* 1.] to the inner and hindermoſt Part, where the optic Nerve O P coming from the Brain, and entering the Eye at P is expanded in a fine white Membrane over all the interior Part as far as to E and D. On this Account 'tis neceſſary all the Parts of the Eye ſhould be perfectly diaphanous or tranſparent, for the free Admiſſion and perfect Refraction of the Rays of Light.

2. Since only a *convev Surface* will converge the Rays of Light to a Focus; the fore Part of the Eye D *e* E has that Figure, and conſiſts of a ſtrong pellucid Coat, which is called the *Corne*, or *Horney-Coat* of the Eye, from its Reſemblance to a Piece of clear *Horn*.

3. The Degree of Convexity or Roundneſs in the *Cornea* D *e* E muſt be ſuch as will converge parallel Rays *a b*, *c d*, nicely to a Point on the *Retina* ln the Bottom of the Eye, and of every diſtant Gbject A B to perform a perfect Image I M on the ſaid optic Nerve.

4. To give a requiſite Convexity to the Eye there is placed a Humour under the *Cornea*, which keeps it protuberant, and is called the *aqueous Humour*, from its Reſemblance to *Water*.

5. If this Convexity of the Eye, or rather of the *Cornea*, be too great as repreſented by the dotted Curve D *b d* E, then the Rays coming from the Object A B, will be converged to a Focus too ſoon, and form an Image *i m* ſhort of the Retina, and in ſuch a Caſe the Viſion will be indiſtinct and confuſed. A Perſon having ſuch Eyes is ſaid to he *purblind*, or *ſhort-ſighted*, becauſe he is obliged to hold Things very near, or at a ſhort diſtance, to ſee them plainly.

6. When the *Cornea* becomes too flat, or has too little Convexity, as repreſented by the dotted Cornea D *b* E, then the Rays coming from diſtant Objects A B tend to a Point beyond the Bottom of the Eye, and form an Image I M, which upon the Retina P Q will be confuſed and imperfect, and the View of that Gbject will be ſo of courſe ; and to ſuch Eyes, the nearer an Object is. the more indiſtinct the Viſion, as is too well known by Experience to moſt Perſons in Years.

7. Next to the aqueous Humour we find a Part D *g f* E, which goes tranſverſly acroſs the Eye, and has, in the human Eye, a round Aperture *f g*, or Hole in the Middle, called the *Pupil*; this Part or Diaphragm (called by Anatomiſts, the *Uvea*) is deſtined to adjuſt a pue Quantity of Light for perfect Viſion ; for by a double Syſtem of muſcular Fibres we can make the Pupil one Half in Diameter leſs, and thereby exclude thre-fourths of the Light,

when

when Objects are too bright and glaring ; and when they are remotely ſituated, and dark, we can make the Aperture or Pupil larger to receive all the Light poſſible in ſuch Caſes.

8. Immediately behind the *Uvea* is ſituated the noble Part called the *cryſtalline Humour* FG, ſuſpended by a Proceſs, or Ring of muſcular Fibres DF, GE ; by Means of which we have a Power of adjuſting the focal Diſtance of the Eye, ſo as to make the Image perfect on the *Retina*, for every Diſtance of Objects ; for the focal Diſtance of the Eye muſt neceſſarily be variable with the different Diſtances of Objects, and is thus wonderfully provided for by this curious Part ; it is in Form of a *Glaſs Lens*, one Side of which is more convex than the other ; it is contained in a fine Tunic or Coat, called the *Arachnoides*, and when diveſted of this, it appears perfectly tranſparent and clearer if poſſible than *cryſtal* itſelf : whence the Reaſon of its Name.

9. After this we find a large Quantity of what is uſually called the *vitreous* or *glaſſy Humour*, filling all the hinder Part, and giving a Body to the Eye ; it fills all the Space DQPE, and is of a very tranſparent Subſtance much reſembling the *White of an Egg*.

10. Theſe three Humours are of different Conſiſtence, yet have all nearly the ſame Denſity and refractive Power ; they accurately provide for all the Circumſtances of *diſtinct and perfect Viſion*, making the Image ſo on the

optic Nerve, expanded over all the Bottom of the Eye in a curious white Membrane, as before mentioned.

11. It is very obſervable, that by the Laws of Optics no Image, I M, will be equally perfect in all its Parts, if formed on a *Plane* or *ſpherical Surface* ; the Form, therefore, of the hinder Part of the Eye can be neither of theſe. And we are aſſured, by bare Inſpection, that the Form Q P of the Fund or Bottom of the Eye is not ſpherical, as Q *k* P, but of a Figure between that and a Plane, that is *truely optical*, and fitted for defining the Image I M equally perfect in every Part.

12. Another Thing remarkable in the Structure of the Eye, is, the Inſertion of the optic Nerve O P, not in the Middle of the Bottom of the Eye, at *k*, but on one Side at P, for this good Reaſon, *that the Rays of Light which fall on the Part* P, *where the Nerve enters the Eye, are loſt*, or the Object is not ſeen by ſuch Rays ; conſequently had the Nerve entered the Eye in the Middle at *k*, the Rays which make the Image in the greateſt Perfection, had then been uſeleſs; and what is worſe, we had ſeen a black Spot in ſuch Objects as we looked moſt directly at ; ſuch wonderful Wiſdom is diſplayed in the Structure of this curious Organ !

I ſhall take no Notice of the well-contrived Apparatus of Muſcles by which the Eye is moveable in its Socket, and directed to any Object at Pleaſure ; it is ſufficient to obſerve that it is every Way conſtructed to anſwer moſt compleatly all the Purpoſes of a *ſcioptric Ball and Socket*, or *Camera obſcura* in Miniature. And as this Inſtrument of Viſion is ſo very precious, and at the ſame Time liable to Defects that muſt be ſupplied by Art, it behoves every reaſonable Man to expect the beſt Succours of this Kind, and to be more anxious, if poſſible, for the Safety and Preſervation of the EYE, than any other Part of the Body; it being beyond Diſpute the higheſt Performance of *divine Mechaniſm*, and the moſt important of all the *Organs of Senſation*.

And now let us ſee how this choice Part has been provided for by Artiſts; truly they have learned to know that a convex Glaſs will magnify, as they call it, an Object placed in the Focus, or ſome where at a Diſtance from the Glaſs; and therefore, without more a-do, clap them upon old Peoples Noſes,to view Objects with them in the beſt Manner they can. But this is far from being the Thing. It is not an indifferent Thing whether a Glaſs be applied to the Eye in this or that Manner; and every one who knows the *Philoſophy of a Pair of Spectacles*, muſt underſtand, that as they ſucceed to the *Collyriums* or Eye-Salves, ſo they may with great Propriety ſtill be reckoned the *Medicines of the Eyes*, and ought to be contrived and applied with the greateſt Skill and Care.

This will more evidently appear from a Compariſon between the Form of *vulgar Spectacles* and thoſe which are here recommended of a new and poiloſophical Conſtrnction. To this End I have repreſented the two Eyes D X E. and D Y E, at the Diſtance they have in the Head with the Spectacle-Glaſſes placed before them at the uſual Diſtance alſo; the firſt of which, *G H*, is that of a *common Pair*, placed right before the Eye D X E; the other G H is one of the *new Form* placed in a proper Manner before the Eye D Y E. [See *Fig*. 2.]

Suppoſe both the Eyes were directed to an Object at a very great Diſtance, the Axes of the Eyes XX and YY, which are rigot Lines paſſing through the middle Points of the Pupil in each, will be parallel to each other as to Senſe, and in this Caſe the Axes of the Eyes would coincide with the Axes of the Glaſſes, and it is in this Caſe only, *viz.* when the Axes of the Eye and Glaſs are the ſame, that diſtinct Viſion can be made, or the Image of an Object be completely formed in the Eye. Now were the Glaſſes deſigned to view very diſtant Objects, the Glaſs G H would be in a proper Poſition. *B*ut this is not the Deſign of Spectacle-Glaſſes, and it is impoſſible to uſe them for any ſuch Purpoſes, at leaſt not *one in a Thouſand* can uſe them to view diſtant Objects; and therefore the *Abſurdity of the Poſition of Glaſſes in common Spectacles* is ſufficiently evident.

For in the next Place, ſince only nigh Objects can be viewed with convex Spectacles, and the Axes of the Eyes are always pointed towards them, in every ſuch Caſe, it is plain, the Axes of the Glaſs and the Eye can be no longer coincident; for let the Object near at Hand to be viewed be A, and both the Eyes turned directly to view it, as they always are; then will the Axes of the Eyes *a* A and a A meet in that Object or Point A, but the Axis of the Glaſs *G H* will ſtill remain where it was, and be far from the Axis A *a* of the Eye, and conſequently there can be no direct or perfect Viſion of the Point or Object A, by the Glaſs *G H* in the common Poſition in Spectacles.

Now let us ſee how the Caſe ſtands with the other Eye, whoſe Axis a A is directed to the Point A, but ſo likewiſe is the Axis of the Glaſs G H, for the ſaid Glaſs is now removed from the Situation *g h* into another G H, which makes the Angle GC*g*, equal to AFY, and conſequently the Axes of the Eye and Glaſs do here coincide, and both become the right Line a C A, paſſing through the Center of the *Cornea* at F, and the Center of the Glaſs at C, and therefore the Viſion of the Object A, or its Image formed in the Eye at a, is as perfect as the Nature of Things can poſſibly admit of.

Again 'tis evident, the Pencil of Rays *G* A *H* which flow from the Point A, and fall on the Glaſs *G H* does, more than Half of it, after Refraction through the Glaſs, paſs on one Side the Eye at A; for even the Axis A *C* of ſthi Pencil, which paſſes through the Center *C* os the Glaſs goes to one Side of the Eye at *D*, and conſequently, that Half of the Pencil *D* A *B*, which lies beyond, muſt all fall off the Eye. And farther we obſerve, that of thoſe Rays which do enter the Eye, by far the greateſt Part are thoſe which are irregularly refracted to it from the Sides of the Glaſs about *H*, and by which the Image of the Point A is rendered very indiſtinct and confuſed. The Reaſon of all which is, that, in this Caſe, the Axis A *D* of the Pencil of Rays, and the Axis A *F* of the Eye make, do not coincide, but make with each other the Angle *D* A *F*.

But with Reſpect to the other Eye at Y, the Caſe is quite altered; for the Glaſs G H is here placed in ſuch a Manner that its Axis coincides with the Axis of the Eye, and both make one Line A F, paſſing through the Center C of the Glaſs G H of the Cornea, and therefore the Pencil of Rays, which form the Point A, fall upon this Glaſs, are by it equally and uniformly refracted to the Eye, and of Courſe muſt make the Image thereof at *a* on the Retina, as diſtinct and perfect as the Nature of Things will admit of. Hence then we make this Inference very juſtly, that in Reſpect of the *Poſition* of the Glaſſes, that in the common Way *G H* is not only *inartful*, but *injurious to Viſion*, while that of the Glaſs G H, according to the new Form, is both conſonant to Reaſon, and what the *Laws of Optics* make neceſſary to view Objects in the beſt Manner.

In the laſt Place, let us but little reflect on the Aperture or Dimenſions of the Glaſſes in the uſual Form, and we ſhall ſoon find that no Regard has been had to the Reaſon of Things, though obvious enough both from Nature and Art; for what Precept or Precedent do they find any where for pouring on the Eyes ſuch a large, unneceſſary, and hurtful Quantity of Light as muſt be refracted through thoſe large Glaſſes of *an Inch and Half in Diameter*, as moſt of them are very nearly. I ſay this Procedure is contrary to *Reaſon*, to *Nature*, and to *Art*.

It is in the firſt Place contrary to Reaſon, for every one knows that Light, by the inconceivable Activity of its Parts is the natural Cauſe of the Diſunion and Diſſolution of the Parts and Contexture of Bodies, and in Proportion as they receive and detain more Light, they are more liable to be impaired and deſtroyed; thus *black Bodies*, by imbibing great Quantities of Light, ſooner become rotten, and are in every Reſpect more ſubject to Decay than *white ones*, which reflect moſt of the Light that fall on them. Too much Light from the Sun when we directly behold it, immediately makes the Eye painful, and Viſion, for ſome Time after, very much confuſed; and there is no Doubt to be made, but that the ſuperfluous

Quantity of Light conſtantly refracted and thrown upon the Eye-Balls by ſuch large Glaſſes, muſt naturally tend to render them *weak and watery* by Degrees; and this Effect we generally ſee attends the Uſe of common Spectacles. Beſides, that Reaſon in all Caſes forbids the Uſe of any Thing farther than is proper to anſwer the End propoſed; and ſince by all Experience it is known, that too much Light is prejudicial in forming the Image of Objects, it muſt be abſurd, in the higheſt Degree, to admit of more than is ſufficient or neceſſary for that Purpoſe in the Eye where Viſion is required to be moſt of all perfect.

Again, it is *contrary to Nature*; for we obſerve in the Eye a particular Proviſion made for adjuſting a proper Quantity of Light for diſtinct Viſion, in the Aperture of the Pupil; and by this the Aperture of the Spectacle-Glaſſes ſhould be limited, that is, they ſhould be ſo large as that the Pencil of Rays from any Point A, refracted through them, ſhould be ſufficient to fill the Area of the Pupil; and if there be any more, as it can't enter the Pupil, it muſt do harm to the other Parts; and therefore ought to be excluded. By this Means we ſhall find the Area of common Spectacle-Glaſſes near three times as large as it ought to be.

And, thirdly, it is a Practice *contrary to Art*; for who does not, or ought not, to know, that in the Structure of a *Microſcope*, *Teleſcope*, *&c.* it is abſolutely neceſſary that there ſhould always be the ſtricteſt Regard to the Aperture of the Object-Glaſs? Since if that be more or leſs than juſt, the Inſtrument will be imperfect; one Degree of Light ſhews an Object diſtinct and fair, when another, greater or leſs, will quite ſpoil the View of it.

Now it is eaſy to obſerve [from *Fig.* 3.] That if the Spectacle-Glaſs A B C be an *Inch and Half Diameter*, as is nearly the common Size, and another Circle *a b c* be deſcribed about the Center *three Fourths of an Inch in Diameter*, then the Light which falls on the Glaſs A B C, will be four Times as much as will fall on the Circle *a b c*; but this Circle will admit of a ſufficient *Field of View*, and the Light full enough for all Purpoſes; and therefore *three Parts in four* of the Light, which falls upon the Eye from common Glaſs A B C is unneceſſary, and not only ſo, but very hurtful, and of Courſe ought to be excluded. And this I do by a large opake Zone or Ring of black Horn *o o o*, as repreſented in the Figure. This *Annulus* of Horn is alſo a Safeguard to the Eye againſt all other foreign or extraneous Light that may come upon it Sideways. But though the Circle *a b c* of three Fourths of an Inch be large enough in Reaſon; yet ſince *Cuſtom*, the great *Tyrant againſt Reaſon*, general has made People expect ſo great a Degree of Light, we have thought proper to indulge them with a circular Area of Light one whole Inch in Diameter, and therefore they ought not to complain. Thus much for the Quantity of Light.

In the laſt Place, as to the *Quality of Light*, it is well known, as we before obſerved, that ſimple or homogeneal Light is much better on all Accounts, than the common compounded or heterogeneous Light, as will be more evident from Fig. 4. where A B C is a Priſm, D E a Beam of the Sun's Light falling upon it at E, from whence it is refracted through it to the other Side at F, and from that Part the Rays now ſeparated are again refracted through the Air to the ſeveral Parts between R and V against the Side of a Room, all at different Diſtances from the Perpendicular F H to the Side of the Priſm. The Part of the Beam which goes to R makes the *red Colour*; thoſa at O an *orange* Colour, at Y a *yellow*, at G a *green*, at B a *blue*, at I an *indigo*, and at V *violet Colour*.

Now ſince the Rays F R are the *leaſt refracted*, they muſt be the largeſt in Magnitude, and ſtrike the Eye with the greateſt Force, and are therefore moſt prejudicial to it. On the other Hand, the Rays F V are moſt of all refracted, which proves that they are of the ſmalleſt Size, and conſequently ſtrike the Parts of the Eye with the leaſt Force; and therefore thoſe Rays, which are of a *violet Colour*, are moſt eligible for the Purpoſes of *Viſion*, both as they form a *more diſtinct Image*, and as their Action is much eaſier to the Eye.

Hence the *vulgar Error* of ſuppoſing *green Rays* make the beſt Light for the Eye is apparent; for blue and indigo Colours are preferable to them; and ſo the yellow, orange, and red, are in order the worſt Colours of Light. Upon the Whole then we learn, both from Nature and Art, that they who would ſee or view Objects with the greateſt Eaſe and Perfection, muſt uſe *viſual Glaſſes* of the Conſtruction and Colour above deſcribed. And a *Word to the Wiſe is enough.* But to others, the Eloquence of *Cicero*, joined with the Sublime of *Longinus* would be loſt. I have done what I can, in a ſmall Compaſs, to open their Eyes, and to make them ſee in the beſt Manner, and according to Art; but if Cuſtom and Prejudice be more prevalent, let them chuſe: *Si Populus vult decipi, decipiatur.*

Since I have propoſed theſe *viſual Glaſſes*, I have the Pleaſure to find they are greatly approved of, and very well received, even beyond my Expectation. The Objections againſt them are few, and ſcarce worth mentioning.——One has ſaid, *he can't ſee to read better in theſe, or find them eaſier to his Eyes than common Spectacles*; that is undoubtedly true, and who would expect a ſenſible Difference immediately, if it be conſidered that the Eye is ſo admirably formed, that it can view an Object tolerably well by Rays of Light refracted upon it in the worſt Manner poſſible? But can this be a Reaſon why Viſion

ſion ſhould not be performed in the beſt Manner? But farther—*they do not find the Light hurt the Eye in one Glaſs more than in the other*—very true; nor do they ſee the *Stone grow hollow by the dripping of Water in Half an Hour*; yet this will be the Caſe in Time; and every wiſe Man looks to the Conſequences in the Uſe of Things of ſo intereſting a Nature.

Another has objected—*that theſe viſual Glaſſes have an uncouth Look, ſit aſkew upon their Noſe, &c.* To which, if any Anſwer be due, I can only ſay, that to a judicious Perſon, whatever is beſt. has the beſt Look; and they ſit moſt properly in that poſition which Nature has directed. But Sir *Francis*—— has a numerous Family, and when their Eyes require Aſſiſtance, 'tis natural to expect they ſhould chuſe *Spectacles*, rather than *viſual Glaſſes*, eſpecially if they have the Privilege of paying a very great Price for them.

I ſhall take no notice of the low Arts that have been practiſed to villify this Invention; they who pretend that I have ſtole it from *ſome old Author*, would do well to produce that Author, leſt their *Veracity* and *Honour* ſhould be called to queſtion; or, what perhaps they would have ſtill leſs diſputed, their *Wit*, in not ſecuring to themſelves what they think, in my Hands, will do them ſuch mighty Harm.

To thoſe who charge me with *underſelling them*, I anſwer, I know not their Prices; and as I have a ſufficient Profit on what I ſell, it proves they have taken *too much* ; for which the Public muſt think themſelves greatly obliged to their Candour and Gratitude.

Laſtly, thoſe whe weakly inſinuate that I *imitate them*, muſt be told, that they publiſh an Untruth ; I have no Reaſon for doing that ; their Inventions are too mean and unſcientifical to deſerve my Notice: I ſell little beſides what I have contrived myſelf ; and my Inſtruments will recommend themſelves to all Judges of Science ; and not only that, but ſave the Public *Cent. per Cent.* in buying. I have only one Favour to aſk of thoſe worthy Gentlemen, and that is, that, ſince they have taken ſo much Pains to depreciate my Inventions, they will act conſiſtent with themſelves, and *not imitate them*.

Let them, who know nothing of *Optics*, make *Spectacles* ; and thoſe, who profeſs not to uſe their Reaſon, buy them: I ſhall always find a Demand for VISUAL GLASSES ; and the generous and judicious Part of Mankind will readily diſtinguiſh between the *Author* of any uſeful Invention, and thoſe who baſely *pirate the ſame*.

DIRECTIONS

For the USE of the

GENERAL APPARATUS

OF

OPTICAL INSTRUMENTS.

I. THE COMPOUND POCKET MICROSCOPE muſt be held in a perpendicular Manner, and the Object to be viewed is to be laid on the concave Glaſs below; and then the inner Part moved gently up or down, will exhibit a clear and pleaſant view of the Object; if it be a tranſparent Object, the Light will be reflected from the Looking-Glaſs below, and ſhew it very plainly. A *Tadpole*, or ſmall Fiſh, is to be placed in the glaſs Tube for viewing the Circulation of the Blood in the Tail, Fins, *&c.* Very ſmall living Objects are to be put into the ſmalleſt Tube to be viewed; or they may be placed in the Concave with a Piece of plain Glaſs over them to confine, yet not bruiſe, them. In the ſame Glaſs you alſo put a Drop or two of Water, Vinegar, *&c.* to view the *Animalculæ* in them. For viewing the larger Sort of ſmall Objects you ſcrew off the upper Part of the Microſcope, and holding the Object juſt under it, or before it, they appear very diſtinct and beautiful. Note, *The Objects to be viewed ſhould always be held in the Sun, or in* *a good Sky-Light* ; they may be placed on long Slips of Glaſs with a little *Gum-Water*, and be laid by for Uſe.

II. *WILSON*'s MICROSCOPE is uſed to view tranſparent Objects, placed between theTalks in the Ivory Sliders, which it magnifies to a great Degree, and with wonderful Perſpicuity. The Circulation of the Blood, *Animalculæ* in Fluids, *&c.* are here ſeen to the utmoſt Advantage in the Glaſs-Tube, placed between the braſs Plates of the Microſcope. The Sliders, or Tubes, being placed between thoſe Plates, you turn the Screw below, one Way or the other, till the Object appears very plain, which it will always do, if you hold up the Inſtrument towards the Sky or Candle. Note, *You muſt turn the Screw, while your Eye is viewing the Object.*

III. The SCIOPTRIC BALL and SOCKET is placed, by Screws or otherwiſe, in a Hole of the Window-Shutter, in a Room made quite dark. Into this Ball you ſcrew the Piece containing a Glaſs only, which will make a curious Picture or Landſcape of all Objects before the Window, or on any Side, by turning the Ball with the Glaſs towards them. The *Colours* are in the higheſt Perfection, the *Motions* all natural, and the *perſpective Scenary* juſt.

IV. The SOLAR MICROSCOPE by Refraction, is the Part to which *Wilſon*'s is ſcrewed on; at the large End it is ſcrewed into the Scioptric-Ball, and there is placed a Glaſs to illuminate the Object (as before) placed between the braſs Plates, in *Wilſon*'s Part; by Means of the Drawer, you may bring the Object near to the Focus of the illuminating Glaſs, and thereby make the Light on the Object as ſtrong as you pleaſe ; then the Tube, being placed in ſuch a Poſition as to receive the Sun's Light through it, by moving the Screw of *Wilſon*'s Part, you will find it eaſy to make the Image very perfect on the paper Screen, or white linen Cloth, placed perpendicular to the Axis of the Microſcope. At ten Feet Diſtance

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2. Then to ſee if it be adulterated, or mixed with baſer Metal, put the Piece of Money in the Loop of the String under the Scale, and the Weight on the Beam to the black Spot, to the right-hand of the Number of Shillings in the Piece, and then let the Money ſink below the Surface of the Water: if then the Beam be horizontal, the Money is all good Gold; but if the Money be too light in the Water, you muſt put ſo many Grains into the Scale as will make an Equilibrium; and then each *Half Grain* will ſhew *one Shilling* and *three Pence* deficient in the Value of the Gold, ſuppoſing it to be mixed with *Copper*, or if it be adulterated with *Silver*, for every half Grain you muſt allow *two Shillings* wanting in Value.

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Any of the above Goods may be ſent, with Expedition and Safety, to any Part of England.

Diſtance the Object will be magnified upwards of a thouſand Times in Length and Breadth, and more than a million of Times in Surface. And in this Way of uſing the *ſolar Microſcope* the *Image* is much more luminous and ſtrong than in the common Way. *Note*, when living Objects, as Mites, *&c.* are to be viewed, they muſt not be brought too near the Focus of the Glaſs, leſt you kill them with Heat.

V. The POCKET TELESCOPE magnifies about ten Times, or brings every Object ſo much nearer to the Eye in Appearance, and therefore the Surface of Objects will be an hundred Times larger ſeen through ſuch a Teleſcope, than when viewed by the naked Eye. There are proper Marks on the Drawers to ſet them by; and that next the Eye muſt be moved a little backward or forwards till you find the true Focus, or moſt diſtinct Appearance of the Object.

VI. The SOLAR TELESCOPE is the ſame Pocket-Teleſcope, adapted to the Ball and Socket, by Means of a Piece of Wood, which on one Side is ſcrewed into the Ball, and on the other it receives the Object-End of the Teleſcope, when the braſs Cap is ſcrewed off; the Teleſcope, being thus fitted on, is to be placed in the Direction of the Sun-Beams, and they will paſs through it, and then, being held ſteady with one Hand, you move the Drawer at the other End a little in or out with the other, and you will ſoon find the Place where the Sun's Face or Image will be made very diſtinct on the Sheet of white Paper held perpendicular to the Rays, and will be larger in Proportion as the Paper is farther removed from the Inſtrument. In this Manner you will eaſily view the *Maculæ*, or Solar-Spots, the Clouds paſſing over the Sun in a moſt beautiful Manner, the Moon paſſing over the Sun in a Solar-Eclipſe, the *Tranſits* of *Mercury* and *Venus* over the Sun's Diſk, and many other curious Purpoſes may be anſwered thereby. *Note*, Before you ſcrew it on to the Ball, the Drawers muſt be all ſet to their Marks or Circles, as when you uſe it in the common Way.

FINIS.

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